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DETERMINING THE EFFICIENCY OF RESPIRATORY CARTRIDGES AND GAS-MASK CANISTERS AGAINST DUSTS AND SPRAYS

By R. A. Fulton and M. S. Konecky, Division of Insecticide Investigations, and Floyd F. Smith, Division of Truck Crop and Garden Insect Investigations

Concern over the inhalation hazard to operators applying dusts, sprays, and aerosols of parathion and other organic-phosphorus insecticides led to a conference, in September 1949, by representatives of several government agencies, and to subsequent meetings with producers of these insecticides and of respiratory protective devices. A cooperative program was set up, under the auspices of the Interdepartmental Committee on Pest Control for the development of respirators and gas masks for the protection of operators while handling these materials. Experimental models of respirators, respirator cartridges, and gas-mask canisters were supplied by the manufacturers. Testing procedures to determine their efficiency were developed and applied by chemists of the Bureau of Entomology and Plant Quarantine, and the results were evaluated jointly by the Department of the Army, Food and Drug Administration, Public Health Service, Bureau of Mines, Production and Marketing Administration, and Bureau of Entomology and Plant Quarantine. Various types of cartridges and canisters were tested against parathion and other organic-phosphorus insecticides and also against dieldrin, aldrin, and chlordane.

As a result of this investigation respirator cartridges that contain a special dust filter have been developed and are now being sold for protection against parathion dusts and sprays (Fulton 1). More recently the same units have also been found effective against dieldrin, aldrin, and chlordane. They are not effective against tetraethyl pyrophosphate, but other units have been developed for that purpose (Fulton, Nelson, and Smith 2).

On May 4, 1950, the Interdepartmental Committee on Pest Control issued a statement concerning these respirators, and listed several commercial respirators that have been found to give such protection. A similar statement concerning devices that will give protection against dieldrin, aldrin, and chlordane was issued by the Bureau of Entomology and Plant Quarantine on August 24, 1951. The methods used for EPN and nicotine are similar to those described for parathion and tetraethyl pyrophosphate.

Test Insects

The chrysanthemum aphid (Macrosiphoniella sanborni (Gill.)), the foxglove aphid (Myzus convolvuli (Kltb.)), and parathion-resistant and nonresistant strains of the two-spotted spider mite (Tetranychus bimaculatus Harvey) were used as test insects.

The chrysanthemum aphid was reared on young chrysanthemum plants in active growth, and the foxglove aphid was reared on potato leaves. The tip of each shoot was removed, and the upper part of the stem was coated with paraffin to force the aphids to feed on the lower expanded leaves. The two strains of the two-spotted spider mite were reared on potted lima bean plants in separate sections of a greenhouse. The varieties Carolina Sieva and Henderson Bush were used, because they are highly resistant to mildew and have relatively small leaves.

Tests of Respirator Cartridges

Apparatus.--The apparatus for testing respirator cartridges is shown in figure 1. It consists essentially of a dusting or spraying chamber (A), a cartridge holder (D), a chamber for exposing the test insects (E), a flowmeter (F) to regulate the flow of air through the apparatus, a manometer (G) to determine the resistance of the cartridge to the air flow, and a unit for sampling the air for chemical analyses. For the tests with parathion the unit shown in H with flowmeter J is used, but for the chlorinated hydrocarbons the air is drawn through a heated quartz tube containing platinum foil to a glass absorption tower (not shown). Chamber A is a glass jar 16 inches in diameter and 30 inches high inverted on a small table in which two holes have been drilled. Into one hole (C) is inserted a tube for injecting the dust or spray into the chamber, and in the other hole is a piece of 1/2-inch pipe (C') for connecting the cartridge holder. At the other outlet of the cartridge holder is another piece of 1/2-inch pipe, which is connected by means of a street elbow and 21-mm. (i. d.) glass tubing to the exposure chamber E, which is a 10-inch vacuum desiccator. From the top outlet of the exposure chamber extends glass tubing to the vacuum pump and the sampling unit, with the flowmeters and manometer inserted in series.

The cartridge holder is shown in detail in figure 2. It was constructed from two floor flanges 4 1/4 inches in diameter made for 1 1/2-inch pipe (A and A'), and provided with gaskets (E and E'). The diameter of the outlets was reduced to fit 1/2-inch pipe by means of two 1 1/2- to 3/4-inch bushings (B and B') and a 3/4- to 1/2-inch bushing (C). The cartridge (D) to be tested is placed between the pipe flanges, and the holder made airtight with 1/4-inch bolts (F).

Tests with Parathion.--For the tests with parathion dusts a wettable powder containing 15 percent of parathion in attapulgite clay was used, and for the test with sprays an emulsion containing 0.16 percent of parathion prepared from a 16-percent emulsion concentrate.

On the evening before a test was to be made portions of mite-infested leaves from the stock mite colonies were pinned to primary leaves on clean young lima bean plants with the upper surfaces together, and the tips and lobes of the bean leaves were cut off. The lima bean plants were placed under 200-watt lamps. During the night the light and mild heat from the lamps stimulated the mites to move from the source leaf to the test leaf. Aphids were taken directly from the stock colony.

In the morning, after the testing apparatus had been assembled, the test leaves infested with aphids and mites were removed from the plants, placed in vials containing water, and set in the exposure chamber (E). A petri dish was used under each vial to catch any insects that might fall from the leaves. Either 0.2 gram of the parathion dust or 1.4 grams of the emulsion was introduced into the chamber A every 5 minutes for 15 minutes or 1 hour. For introducing the spray a hydraulic sprayer that produced a mist with an average particle size of 55-58 microns was used. These particles were found to settle at about the same rate as the dust particles.

Air was drawn through the apparatus by means of a vacuum pump, at the rate of 16 liters per minute for cartridges for dual-type respirators and 32 liters for cartridges for single-type respirators.

For chemical determinations samples of air were drawn through the sampling unit, which contained 5 ml. of absolute alcohol, at 1 liter per minute. At the end of the sampling time the alcohol from each unit was transferred to a volumetric flask, rinsed twice with 2 to 3 ml. of alcohol, and made up to 10 ml. with alcohol. The optical density was determined with a quartz spectrophotometer at a wave length of 274 millimicrons and compared with a previously prepared optical density-concentration curve (fig. 3).

For the biological tests, after the exposure each leaf bearing aphids or mites was transferred to a vial standing in a beaker. A layer of paraffin in the beaker supported the vial and provided a light-colored surface on which fallen aphids or mites were readily observed, and a coating of lanolin on the rim prevented the survivors from escaping. Mortality counts of aphids were made after 4 to 6 hours. Affected individuals were shriveled, and a yellow exudate was usually present at the opening of the cornicles. Mites were usually examined at the same time, but always within 24 to 30 hours after they had been transferred to test leaves, to reduce the occurrence of newly hatched nymphs or new adults. Any that did appear were usually recognized by their lack of pigmentation. Aphids and mites that survived these tests were never returned to the stock colonies.

Typical results obtained with parathion dusts are presented in table 1. Three types of cartridges were exposed to the dust-laden air in conjunction with the filters with which they would be used under practical conditions. The air was drawn through the apparatus at the rate of 16 liters per minute and the exposure period was 1 hour.

Table 1.--Results of tests of three respirator cartridges against 15-percent parathion dust

Cartridge type	Weight of dust on cartridge filter	Resistance of cartridge to air flow		Parathion passing through cartridge		Mortality of aphids after--	
		Initial	Final	First 10 min.	Last 10 min.	First 15 min.	Last 15 min.
	Milligrams	Inches of water		Micrograms		Percent	
A	172	0.5	1.0	0.45	0.45	61	18
B	185	.4	.75	.50	.50	35	22
C	180	.5	.81	.35	.40	42	28

Tests with Tetraethyl Pyrophosphate.--No chemical analysis was made to evaluate the amount of tetraethyl pyrophosphate passing through the cartridges, but only biological tests with aphids. The procedure was the same as for parathion, and the tests were made with a spray prepared by diluting a 38 to 40 percent emulsion concentrate (or wettable powder) to contain 1 part of tetraethyl pyrophosphate in 200 parts of water.

In typical tests this spray was used on activated-charcoal cartridges in conjunction with two types of filters. Aphid mortalities determined after 60 minutes' exposure were as follows:

	Percent
Cartridge plus--	
Dust filter	100, 99.2, 99.3
Fume filter	14.0, 10.4, 4.5
Fume filter without cartridge	12.9

These results indicate that the dust filter in conjunction with an activated-charcoal cartridge will not remove tetraethyl pyrophosphate but that the fume filter is effective even without the cartridge. The fume filter is made to stop particles as small as 0.01 micron in diameter.

Tests with Chlorinated Hydrocarbon Insecticides.--Dieldrin was used both as a dust and as a spray, but aldrin and chlordane only as dusts. The concentration was 5 percent in all cases. The dieldrin and aldrin dusts were prepared by grinding the technical material with synthetic magnesium silicate, and the chlordane dust contained attapulgite clay as the diluent. The sprays were prepared from 25-percent emulsifiable concentrates. The effectiveness of the cartridges was tested only by chemical analyses; no insect-mortality tests were made for these materials. Samples of air that had passed through the cartridges were drawn through the quartz tube containing platinum foil heated to a bright red to the absorption tower containing glass beads that had been wet with a chlorine-free solution of sodium carbonate containing arsenic trioxide (1 gram of arsenic trioxide to 80 ml. of saturated sodium carbonate solution and 20 ml. of distilled water). At the end of the sampling period the beads were washed with distilled water. The washings were transferred to a Nessler tube, acidified with nitric acid, treated with an excess of silver nitrate, made up to volume, and the chlorine determined by the turbidimetric method.

The results of typical tests with several respirator cartridges in conjunction with dust filters are shown in table 2.

Table 2.--Results of tests of respirator cartridges with dust filters and of a fume filter alone against aldrin, dieldrin, and chlordane

Type of cartridge	Insecticide passing through cartridge (micrograms per liter)			
	Dieldrin		Aldrin dust	Chlordane dust
	Dust	Spray		
A	0.4	0.6	0.4	0.3
	.6	.4	-	-
	.2	-	-	-
B	.4	.8	.8	.3
C	.2	-	-	.3
	.3	.6	.3	.3
D	1.1 1/	-	-	-
Fume filter only	2.9	3.6	-	-
	1.2	-	-	-

1/ In each of 3 replications.

Tests of Gas-Mask Canisters

The apparatus for producing vapors for the testing of gas-mask canisters is shown in figure 4. Air is passed at the rate of 1/2 liter per minute through a fritted-glass bubbling unit (A) and then through a column of glass beads (B) to remove small particles that might be carried in the air stream. The insecticide is allowed to drip into B from the separatory funnel (D) throughout the test period to keep the beads covered at all times. A small drying tube (C) removes the moisture from the air entering the funnel. The excess liquid is trapped in a flask (E). The outlet (F) of the column is connected directly to the canister holder. The sampling unit and the insect-exposure chamber are the same as for the cartridge tests (fig. 1). To maintain a uniform temperature the entire apparatus is placed in a large constant-temperature box. All the tests reported were made at 85° F.

Technical parathion, a product containing 38 to 40 percent of tetraethyl pyrophosphate, and technical tetraethyl dithiopyrophosphate were used to produce the vapors.

The efficiency of the canisters was determined only by biological tests. The test insects were the same as for the tests of respirator cartridge.

In tests of three commercial brands of canisters designed to remove organic vapors, acid gases, fumes, and dusts, an air stream containing 60 micrograms of parathion vapor per liter gave 2, 1.7, and 0 percent mortality after 60 minutes' exposure as compared with 100 percent mortality of aphids after 10 minutes' exposure to vapors that had not passed through a canister.

Tests of similar canisters against tetraethyl pyrophosphate and tetraethyl dithiopyrophosphate vapors gave similar results.

Summary

Procedures have been developed for evaluating the efficiency of respirator cartridges in protecting against dusts and sprays of agricultural insecticides and of gas-mask canisters against vapors of these materials. These methods have been used to test cartridges and canisters for their effectiveness against parathion, tetraethyl pyrophosphate, tetraethyl dithiopyrophosphate, aldrin, dieldrin, and chlordane. Results of some typical tests are presented.

Literature Cited

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(2) ______ Nelson, R. H., and Smith, F. F.
1950. The toxicity of lindane vapor to insects. Jour. Econ. Ent. 43: 223-224.

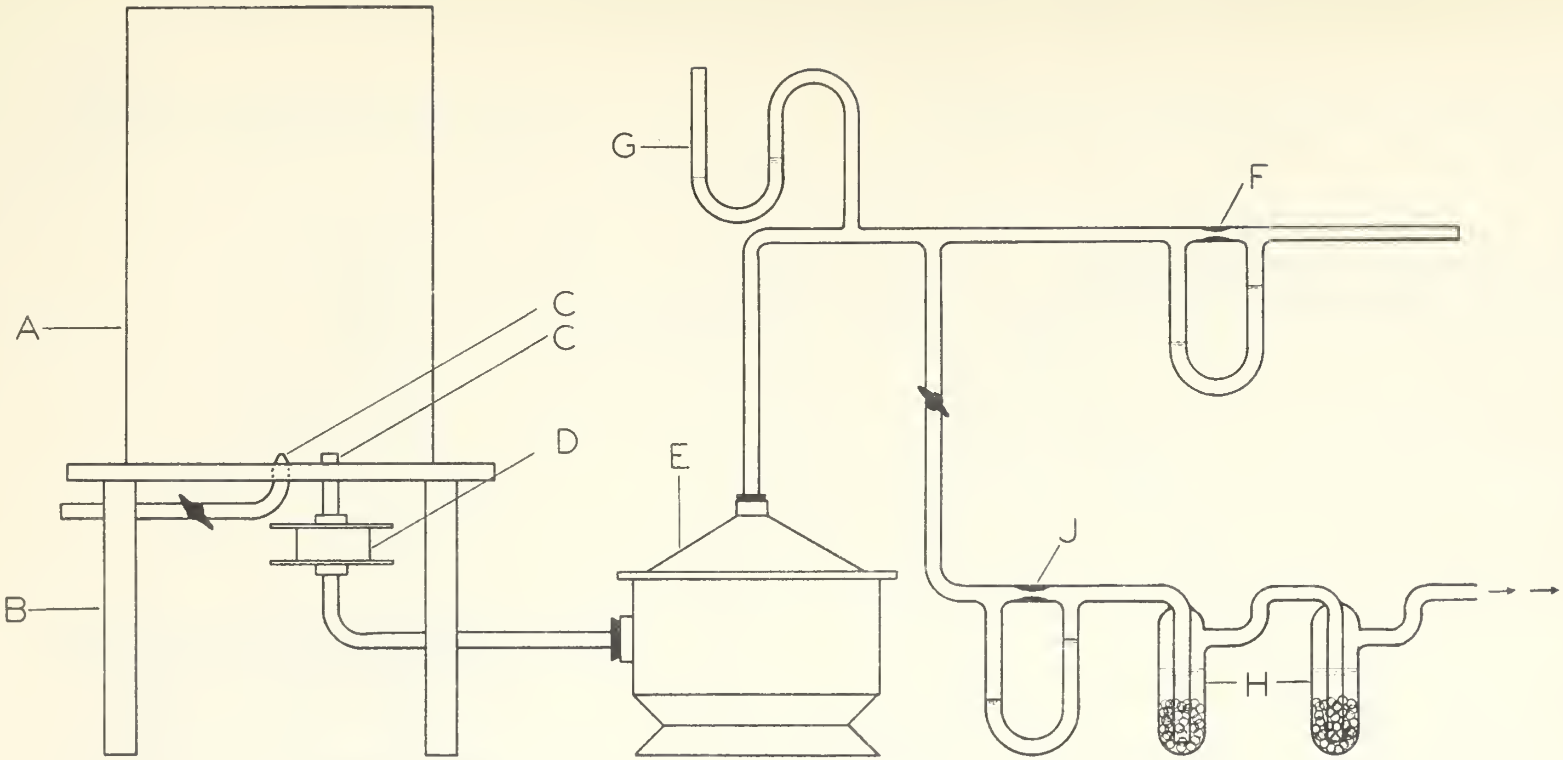

Figure 1. --Diagrammatic sketch of apparatus used to test chemical cartridges and dust filters.

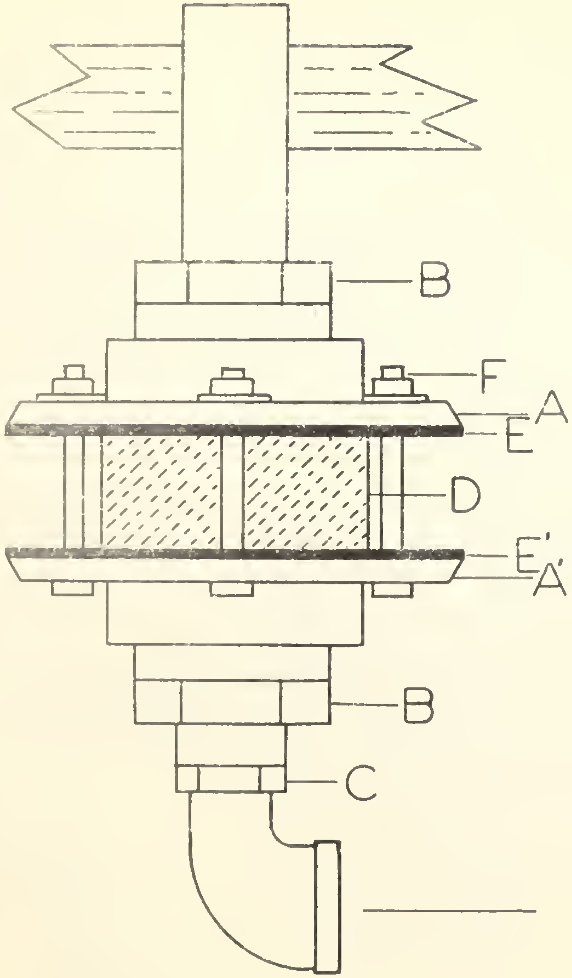

Figure 2 --Chemical cartridge holder showing position of test unit.

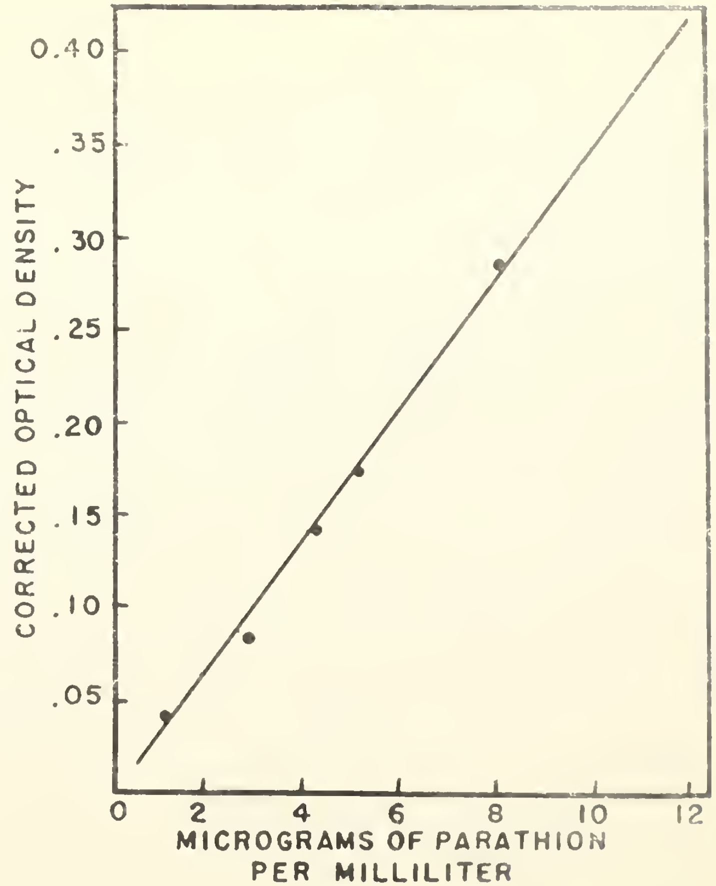

Figure 3. --Calibration curve made with pure parathion at 274 millimicrons wave length.

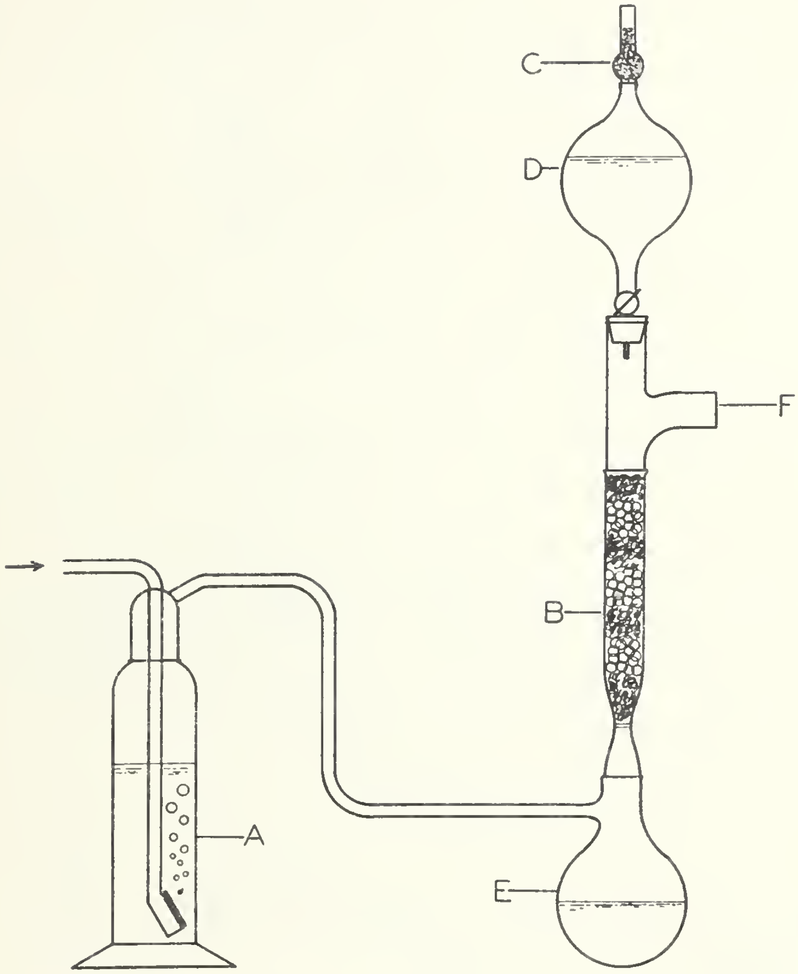

Figure 4. --Apparatus used for saturating air with organic phosphorus compounds.